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ABSTRACT

Enrollment forecasting is a subject for scholars of varied interests and concerns. The literature reflects several perspectives, including those of school administrators, facilities planners, mathematicians, statisticians, demographers, and computer programmers. This pamphlet contains an analysis and annotated bibliographies of 29 publications on enrollment forecasting that are available in the ERIC system. (Author/MLF)

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ENROLLMENT FORECASTING

By Philip Piele and Darrell Wright

Enrollment forecasting is a subject for scholars of varied interests and concerns. The literature reflects several perspectives, including those of school administrators, facilities planners, mathematicians, statisticians, demographers, and computer programmers.

Two perspectives are prominent. One presents the problems of administrators and facilities planners who detect impending or current enrollment decline. Another perspective expresses the concerns of mathematicians, statisticians, and demographers who detect weaknesses and inaccuracies in the forecasting models. The administrators accept the responsibility to accurately and appropriately inform the public about the need for teachers and facilities and to prepare for social and political problems arising from school closure. They have decisions to make.

The math people accept the responsibility to provide tools that produce accurate and appropriate enrollment forecasts. They have models to make.

For decision-makers and model-makers, the common denominator rests in the persistent question of how many students will enroll in the public schools during the next year, the next five years, the next ten years.

The *decision-makers* have problems that arouse emotions and strain rational behavior. Superintendents must prepare budgets based on a changing student enrollment. Personnel administrators must hire the correct number of teachers and justify class size to teacher unions and the public. Facilities planners must anticipate space needs and demonstrate efficient building utilization. School board bargaining with employee unions must be

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based on accurate information. Accurate enrollment forecasts are vital to all these decisions.

Basic to enrollment forecasting is a thorough knowledge and understanding of the community and how it grows. Engelhardt and Ireland are two authors who emphasize the community factors. An essential ingredient for community understanding is a knowledge of the population trends. Is the community growing or declining and why? A second factor involves the plans of the business and civic sectors. Are new businesses being planned or are old businesses dying? Will a new freeway displace homes and schools? A third factor suggests that current trends be considered in relation to the history of the community. What has happened to school enrollment in relation to business changes in the past?

The literature suggests that enrollment forecasting escapes the realm of numbers and leads to entangling questions of social pressure and political influence. Can pressure groups who don't want schools to close affect local enrollment projections? Fascione and Herron suggest that political influence is a reality in enrollment forecasting. Can ethnic differences in life-style affect forecasting models? Some authors forecast black and white populations separately. Can a sharp increase in private school tuition distort a carefully prepared projection? Ackerman, Post, and Weiss note that if the students opt for public schools in reaction to a tuition raise, the answer can be yes.

Most authors agree that political, social, economic, and historical trends that influence a community are considered vital to the effective development and use of enrollment forecasts for decision-making.

The *model-makers* have different problems but a related purpose, which is the building of better, more accurate models. The reader may select articles from the literature that range along a continuum from mathematical simplicity to complexity. Engelhardt (1974) presents a primer with step-by-step directions that introduce enrollment forecasting to those unsophisticated in statistics. Several authors present formulas and formula modifications that can be appreciated by mathematicians.

The continuum holds places for the computer-oriented reader as well. Ackerman, Post, and Weiss present a program in use by a local school district, and Denham suggests a program that includes probabilities as results.

A foundation for enrollment forecasting is developed by Charters as he presents a logic of prediction. Whatever formula is used, he notes that the method must contain three essential components: a criterion variable whose values need to be estimated, one or more predictor variables whose values are known, and an operator that quantitatively expresses the relationship between the predictor and the criterion variable.

Among the various techniques for applying a mathematical model to enrollment forecasting, a cohort-survival method is frequently mentioned and very often criticized. Several writers find weaknesses in cohort-survival methods that lead to inaccurate projections. McNamara proposes a modification to allow introduction of new data. Li proposes using renewal theories of demographic analysis to modify a cohort-survival model. Other writers suggest alternative techniques such as the Markov Chain and multiregression models. McIsaac and others and Denham propose developing probability distributions that provide the user with a range of results to be used at a risk level chosen by the user.

The use of enrollment forecasts, as Ireland suggests, can be effective and beneficial if the user holds three basic attributes. He would have the user know the community and its uniqueness. Then, the user should apply an appropriate forecasting model regularly and often. Finally, the user is asked to consider accepting probabilities as effective results.

Taken collectively, the concerns of model-makers arise from a desire to develop accuracy in enrollment projections of enrollments that the decision-makers may use with assurance. The user is asked to become aware of the weaknesses some methods inherit, to be cognizant of alternatives and modifications, and, at the very least, to report the results as probabilities rather than revelations.

Ackerman, Jerry; Post, Arnold; and Weiss, Edmond H. *STEP, Year 1, Volume III: An Enrollment Forecaster for STEP.* Philadelphia: Government Studies and Systems, [1971]. 38 pages. ED 056 373.

A computer forecasting model for Trenton, New Jersey, public schools is presented with facts, figures, and rationale. The input includes statistical average relationships of data relating to population mobility, enrollment patterns, and

William Rainey Harper Community College, Palatine, Illinois. Photo courtesy of Caudill Rowlett Scott, Architects.

enrollment adjustment by busing. Urban renewal, building development plans, and the subjective judgment of school principals are also considered.

Seasonal enrollment changes and raises in private school tuition are local factors affecting enrollment change in this mobility analysis model, which treats black and white populations separately. This model for a specific school district can be read for its generally applicable concepts.

Order from EDRS. MF $0.76 HC $1.95. Specify ED number.

Braden, Barbara, and others. *Enrollment Forecasting Handbook Introducing Confidence Limit Computations for a Cohort-Survival Technique.* Newton, Massachusetts: New England School Development Council, 1972. 60 pages. FD 066 781.

A 1968 study by the New England School Development Council concluded that errors in enrollment forecasting are due to changing local trends rather than to forecasting methodology. To account for changing conditions, the study proposes an application of confidence interval techniques to a cohort-survival method.

This handbook presents sections on the cohort-survival method, use of confidence intervals, collection of data, and calculation of enrollment forecasts. Sample work pages are included to assist the reader in developing enrollment forecasts.

Order copies from New England School Development Council, 55 Chapel Street, Newton, Massachusetts 02138. $3.50.
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Brown, Daniel J. "A Smoothing Solution to the School District Enrollment Projection Problem." Paper presented at the American Educational Research Association annual meeting, Washington, March-April 1975. 29 pages. ED 103 970.

Brown delves into the complexity of mathematical forecasting models. He discusses the advantages and disadvantages of a number of available models and then applies the exponential smoothing model to data from three different school districts. The model's projections are found to correspond well with actual enrollments. According to Brown, school districts with their presently limited expertise and technology would be able to utilize this model for their own planning purposes.

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Brunetti, Frank. "Enrollment Decline. Major Issues for '75." *CEFP Journal,* 12, 4 (July-August 1974), pp. 10-12. EJ 102 573.

Declining enrollments present school administrators, facilities planners, and enrollment forecasters with a new set of problems. Fewer students may mean closing schools and reducing staff. To detect an impending decline, forecasters may examine city and county demographic factors and the rate and nature of land use development, which have a direct effect on school enrollments.

An important statistic for educational planners is the rise or decline of birth rates. Calculations of kindergarten-to-sixth-grade ratios each year will indicate the enrollment replacement power. If the survival ratio falls below 1.00, the enrollment has reached zero growth.

Early detection from the warning signs suggested in this article can aid in reducing the pains of consolidating and reducing operations.

Carss, Brian W. "A Multiregression Model for Predicting Enrolments in the First Seven Grades of the Queensland State School System." *The Journal of Educational Administration,* 11, 1 (May 1973), pp. 69-78. EJ 085 983.

W. D. Wilkerson Intermediate School, Conroe (Texas) Independent School District. Photo courtesy of Golemon & Rolfe, Architects.

Because educational planners have not found trend analysis procedures adequate for changing systems, Carss proposes a multiregression model for enrollment forecasting. Tested against historical enrollment data, the proposed multiregression model could account for 99.49 percent of the variance of the criterion variable. This application is similar to a moving-least-squares model.

Central Connecticut Regional Planning Agency. *School Enrollment Projection Techniques.* Plainville, Connecticut: 1970. 23 pages. ED 056 418.

The Central Connecticut Planning Agency presents an enrollment projection manual including techniques to be used in 1-5 year projections, 6-20 year projections, and projections beyond 20 years. The shorter-range technique uses average percentage relationships in birth and enrollment data. The longer-range techniques employ a cohort-survival method. Explanatory tables are included.

Order copies from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. PB-200-424/LK. MF $2.25 HC $3.25.

Charters, W. W., Jr. "The Logic behind Enrollment Forecasting." *Administrator's Notebook,* 19, 8 (April 1971), pp. 1-4. EJ 041 230.

Charters discusses the general logic of statistical prediction in relation to enrollment forecasting. Prediction requires a criterion variable, predictor variables, and an operator that quantitatively states the law connecting the predictor and criterion variables. He concludes that forecasting effectiveness of operators can be assessed by postdiction, inspection of internal error, and theory testing.

Denham, Carolyn H. *Probabilistic School Enrollment Predictions Using Monte Carlo Computer Simulation. Final Report.* Chestnut Hill, Massachusetts: Boston College, 1971. 171 pages. ED 062 729.

Denham proposes probability distributions in school enrollment predictions to alleviate inaccuracies in enrollment forecasting methods. Using a multivariable forecasting method as the base for Monte Carlo computer simulation programs, multiple predictions in the form of probability distributions are produced. The proposed model requires an internal examination of the system, an estimation of the probabilities for each of the parts, and the use of the probabilities to determine probabilistic information about the system as a whole.

The author intends to overcome a recognized lack of communication between the forecaster and the user.

Order from EDRS. MF $0.76 HC $8.24. Specify ED number.

Engelhardt, N. L. "How to Estimate Your Future Enrollment." *School Management,* 17, 6 (June-July 1973), pp. 38, 40-41. EJ 078 823.

Intelligent enrollment forecasting demands an understanding of the community, careful weighing of many factors, and common sense. Engelhardt suggests that the growth and decline trends in population, shifts in birth rates, new housing units, and ethnic demography are important factors. He concludes this primer by generally describing a four-step forecasting method based on the cohort-survival technique.

Engelhardt, N. L. "Here's a Five-Year Plan for Forecasting." *Nation's Schools*, 93, 5 (May 1974), pp. 51, 54. EJ 096 652.

This brief article provides a straightforward four-step plan for predicting enrollment increases or decline. The steps are illustrated and helpful to those who lack computer assistance and shun mathematical models. What mystery is created by formulas elsewhere is made obvious with words and columns of numbers here.

Fascione, Daniel R., and Herron, William P. "Projecting School Enrollments: A Research or Political Process?" Paper presented at American Educational Research Association annual meeting, New York, February 1971. 12 pages. ED 047 369.

Where school budgets are built on the results of enrollment forecasting, the statistics may be influenced by political factors. Fascione and Herron describe the effect of special interest groups on the data used in enrollment forecasting and warn that unrealistic results may leave educational needs unmet.

Order from EDRS. MF $0.76 HC $1.[illegible]. Specify ED number.

Fredrickson, John H. "Effective Planning for Your District." *School Management*, 18, 4 (April 1974), pp. 30, 33, 44. EJ 094 622.

In nontechnical language, Fredrickson places enrollment forecasting in a planning perspective for facilities preparedness. The popular cohort-survival technique for enrollment forecasting is described generally without using mathematical formulas or numbers.

Enrollment forecasting, according to Fredrickson, is one of eight steps to effective planning.

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Gilmore, William, and others. *ENSIM. A User's Manual for a Land Use Analysis-Based Enrollment Simulation. Research Report No. 11 of Project Simu-School: Santa Clara County Component.* San Jose, California: Santa Clara County Office of Education, 1974. 240 pages. ED 096 751.

ENSIM is a multivariable method for computer-based long-range enrollment simulation. Designed for use in a growing school district, the method considers the traditional district information such as census and enrollment data, but also adds new data concerning social, economic, political, and demographic factors to predict the extent and location of enrollment growth. The central feature of the ENSIM model is a future land development projection system to provide the forecaster with data on the number of projected new houses. A probabilistic input model developed by Dr. Carolyn Denham provides the computer program.

The document contains a complete computer program description, rationale, documentation, and case study of an application of the ENSIM method to a local school district.

Order from EDRS. MF $0.76 HC $12.05. Specify ED number.

Ireland, Robert S. "Improving the Art of School Enrollment Forecasting." *Catalyst for Change*, 1, 2 (Winter 1972), pp. 26, 27, 29. EJ 055 433.

The art of enrollment forecasting, according to Ireland, lies in a thorough knowledge of a community's history, trends, and plans combined with regular and frequent application of statistical forecasting methods. He suggests using upper and lower limits of predicted enrollments for planning and emphasizes the importance of calculating the random error in statistical procedures.

Jaffe, A. J. *Handbook of Statistical Procedures for Long-Range Projections of Public School Enrollment. Technical Monograph.* Washington, D.C.: Office of Education (DHEW), 1969. 131 pages. ED 058 668.

This methodology handbook provides an array of enrollment forecasting procedures emphasizing long-range projections. The text presents general observations on statistical forecasting procedures, a history of local application problems, short-range projection methods, a unified method for state level forecasting, and long-range projection methods. Thoughtful discussion of projection problems and weaknesses are included.

Jaffe expresses preference for long-range projections that are periodically altered with new data and checked against current empirical data.

Ample illustrative material is included in appendixes.

Order from EDRS. MF $0.76 HC $6.97. Specify ED number.

Johnstone, James N., and Philp, Hugh. "The Application of a Markov Chain in Educational Planning." *Socio-Economic Planning Sciences*, 7, 3 (June 1973), pp. 283-294. EJ 080 524.

Although the Markov Chain model for enrollment forecasting is widely used, Johnstone and Philp found a basic inflexibility in the model. The authors applied the Markov Chain to actual enrollment data in New South Wales, Australia. Although they experienced some success, they noted the model to be inflexible in accommodating transition rates that can be observed by inspection.

The authors conclude that if a model cannot predict values for enrollments in past years, then values predicted for future years cannot be accepted.

Keough, William F., Jr. "Early Warning Signs of an Enrollment Drop." *School Management*, 18, 7 (August-September 1974), pp. 32, 36, 37. EJ 104 111.

The cohort-survival method for enrollment forecasting has been a popular technique for predicting growth or decline, but this article suggests using other sources. Ongoing study of residential construction plans and changes in zoning requirements, developments of open spaces and reclaimed land, information from municipal planning offices, studies from utility companies, and business-industrial employment practices are suggested factors school administrators may examine to detect enrollment decline possibilities.

A set of questions is posed to which a superintendent's answers will provide a basis for predicting enrollment changes.

Leggett, Stanton. "How to Forecast School Enrollments Accurately—and Years Ahead." *The American School Board Journal*, 160, 1 (January 1973), pp. 25-31. EJ 067 465.

Because evidence suggests that public school enrollments are declining, Leggett warns educators to be prepared through enrollment forecasting. Major changes in building patterns, community patterns, nonpublic schools, transportation, integration of races, and national trends are warning signs. To forecast, Leggett presents a step-by-step explanation of a cohort-survival ratio method that is clearly stated and easy to follow.

Li, Wen L. "A Demographic Model of Student Progression." *International Review of Education*, 17, 4 (1971), pp. 408-424. EJ 057 961.

Li proposes an enrollment forecasting model using renewal theories of demographic analysis. Assuming the educational system is a closed system, the size of the student cohort survival is affected by mortality, dropout, and retention. Li presents a conversion technique to obtain grade-specific dropout and mortality rates; he solves the recursive equations to obtain the repetition rate. He suggests that these modifications will produce more accurate forecasts.

McIsaac, Donald N., and others. *Enrollment Projections. ENROLV2.* Madison: Wisconsin Information Systems for Education, Wisconsin University, 1972. 52 pages. ED 074 715.

Using FORTRAN language, ENROLV2 is a program designed to forecast public school enrollments. Beginning with grade enrollments, the program extends the data according to any of six user-specified methods including averaging and regression methods. Next, the program computes projections employing a survival-ratio method or a linear-regression method. The reliability of obtained estimates is computed in the program. This report contains explanation of the computer program with sample input and output data.

Order from EDRS. MF $0.76 HC $3.32. Specify ED number.

McNamara, James F. "A Modification of the Age-Cohort Method for Projecting First Grade Enrollment." *Planning and Changing*, 3, 2 (July 1972), pp. 51-57. EJ 064 182.

Because of weaknesses in the cohort-survival technique of enrollment forecasting, McNamara developed a modification that gives weight to recent experience data. The rationale is similar to Bayesian statistics where initial ratios or probabilities are adjusted when new data are obtained.

McNamara recognizes the need for accuracy in educational planning and suggests this modification as one expedient method.

New York State Education Department. *Procedures for Projecting School District Enrollment.* Albany: Information Center on Education, 1974. 18 pages. ED 099 963.

New York State's Information Center on Education presents a how-to-do-it lesson on enrollment projecting using the cohort-survival technique. The basic model, modifications, sample work sheets, and step-by-step procedures are included for administrators to use in forecasting enrollment in their local districts for short-term planning. The guide cautions administrators about local factors that affect enrollment forecasts and subsequent adjustments, advising that a model should not be applied mechanically and that judgmental decisions are necessary.

Order from EDRS. MF $0.76 HC $1.58. Specify ED number.

New York State Education Department. *Projections of Public and Nonpublic School Enrollment and High School Graduates in New York State: 1974-75 to 1992-93.* Albany: Information Center on Education, 1974. 20 pages. ED 099 961.

This report contains graphs and tables presenting New York State public and nonpublic school enrollment projections, based on the application of a modified version of the cohort-survival model. Estimates of future enrollments are based on actual birth figures, population estimates, and projected age-grade matrices.

The projection of high school graduates is determined from grade 12 enrollment estimates. Regional estimates of public enrollment are obtained by apportioning the first grade estimates for the state according to the historical trend in the various regions. Procedures followed in making these projections are explained in an appendix.

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Organisation for Economic Cooperation and Development. *Mathematical Models in Educational Planning. Education and Development, Technical Reports.* Paris, France: 1967. Papers presented at Organisation for Economic Cooperation and Development meeting, March 1966. 290 pages. ED 024 138.

Can systems analysis develop comprehensive quantitative

approaches to apply to global educational planning problems? The general conclusion of international authors presenting papers at the 1966 meeting of the Organisation for Economic Cooperation is affirmative. They see considerable promise for improving the reliability of forecasts as a base for educational planning. The papers examine various possibilities of applying a number of related techniques, such as mathematical model building and simulation, to the problems of educational planning.

Order copies from Organisation for Economic Cooperation and Development Publications Center, Suite 1207, 1750 Pennsylvania Avenue, NW, Washington, D.C. 20006. $3.80.
Also available from EDRS. MF $0.76 HC $14.59. Specify ED number.

Simon, Kenneth A., and **Frankel, Martin M.** *Projections of Educational Statistics to 1983-84. 1974 Edition.* Washington, D.C.: National Center for Education Statistics (DHEW), 1975. 177 pages. ED 105 590.

This publication provides projections of statistics for elementary and secondary schools and higher education institutions, including enrollments, graduates, teachers, and expenditures covering a period from 1974 to 1984. These statistics assume that the trends in enrollment rates, retention rates, class size, and per-pupil expenditure will continue through 1984. Methodology is presented in the appendix.

Order copies from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. $2.50.
Also available from EDRS. MF $0.76 HC $9.51. Specify ED number.

Tatham, Elaine L., and **Finch, Harold L.** "A Computer Model for Demographic Projections in Educational Planning." Paper presented at the Conference on Population Projections and Related Futures, Toronto, November 1974. Overland Park, Kansas: Institute for Community/College Development, Johnson County Community College, 1974. 47 pages. ED 101 786.

Fodrea Community School, Columbus, Indiana. Photo courtesy of Caudill Rowlett Scott, Architects.

Of interest to community college administrators faced with declining enrollments is this case study of a college's computerized planning model for projecting realistic future enrollments. Tatham and Finch describe the demographic planning model in detail and demonstrate the system with a complete demographic analysis of future population and enrollment trends in a hypothetical county. They also note alternative uses of the model in community planning.

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Wasik, John D. *A Review and Critical Analysis of Mathematical Models Used for Estimating Enrollments in Educational Systems.* Raleigh, North Carolina: Center for Occupational Education, North Carolina State University, 1971. 28 pages. ED 059 545.

Wasik surveys and reviews existing mathematical enrollment forecasting models and organizes them in three categories that he calls extrapolation by survival cohort or cohort regression, structural flow, and Markov type procedures. The bibliography lists sources of mathematical models used for enrollment forecasting that Wasik states are mainly of recent origin.

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Webster, William J. "An Empirical Comparison of Selected Enrollment Projection Formulas." *The Journal of Educational Research,* 64, 8 (April 1971), pp. 375-381. EJ 035 924.

This study examines the accuracy of enrollment projections when relating selected ratio and regression formulas to differences in community growth characteristics and to differences in the education level. Seven projection formulas, including the popular cohort-survival formula, were applied to a sampling of Michigan school districts.

Results indicate positive relationships between accuracy of projection and the community growth and education level variables. Webster suggests that educators working with incomplete data could most appropriately use a linear least-squares equation for enrollment forecasting.

Werdelin, Ingvar. "A School Enrolment Model." *International Review of Education,* 16, 2 (1970), pp. 192-214. EJ 027 624.

Werdelin's concern is to develop an enrollment model for an entire country, which would give clues to a school district for the collection of information. This model becomes a framework on which various enrollment projection methods may be fastened, or which may serve as a background for the creation of better projection methods. He states that such an abstract model facilitates the study of relationships between variables in a semiexperimental way. The model presented deals with the probabilities that certain events will occur within the population.

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